Codes and coding: Sebeok's zoosemiotics and the dismantling of the fixed-code fallacy

Paul Cobley

Abstract:

The concept of code has a long and varied history across the sciences, the social sciences and the humanities. In the interdisciplinary field of biosemiotics it has been foundational through the idea of code duality (Hoffmeyer and Emmeche 1991); yet it has not been free from controversy and questions of definition (see, for example, Barbieri 2010). One reason why code has been so central to modern semiotics is not simply a matter of the linguistic heritage of semiology and the work of Jakobson who straddled both semiology and semiotics. Rather, it has been the programmatic reconceptualization of code which is woven through the work of modern semiotics' founder, the father of both biosemiotics and zoosemiotics, Thomas A. Sebeok. A biologist manqué, a communication theorist influenced by cybernetics and a semiotician deriving from the 'major tradition' of Peirce, arguably Sebeok's most systematic considerations of code were offered in his essays on zoosemiotics, largely from his 1963 coining of the term onwards. This article principally revisits the 1972 collection of Sebeok's zoosemiotic essays and suggests that his particular observations in respect of analogue and digital codes and their relation to evolution in the world of animals harbours an opportunity to rethink and potentially resolve, through an ethological lens, current controversies regarding the status of code.

Key words: code, coding, semiotics, zoosemiotics, biosemiotics, communication, linguistics, segregational perspective, integrationist perspective.

Introduction

Most accounts of code are not self-reflexive. They seldom define code, nor do they give a sense of their history. In textbooks on mathematics, computing, information theory and cryptography, the discussion of codes begins with entropy and algorithms, the status of codes and their ontology (see, for example, Welsh 1988, McEliece 2002). Some mathematics textbooks allocate time to defining the concept of code; hence, Biggs (2008: v) states that coding is

> replacing symbolic information, such as a sequence of bits or a message written in a natural language, by another message using (possibly) different symbols. There are three main reasons for doing this: Economy (data compression), Reliability (correction of errors), and Security (cryptography).

Yet this seems a rarity. In my own subject area - communications, media, cultural studies – the notion of 'codes' and 'coding' is omnipresent where any consideration of the semiotics of communications are on the agenda (partly as a result of the subject's celebration and serial anthologization of one seminal Eco-influenced essay – Hall 1973). In large-scale attempts to define the subject area (e.g. Donsbach 2008), that omnipresence also becomes nebulous, disparate (see Craig 2008) and difficult to reduce to the kinds of laws characteristic of mathematics. Even in 'classic' semiotics, the self-reflexiveness is absent: Eco (1976)

launches straight into post-Shannon communication theory, deeming the self-reflexive questioning of code unnecessary because it entails just four different phenomena: a) a set of signals ruled by internal combinatory laws, b) a set of states of an entity which are taken into account as a set of *notions* about the state of that entity, c) a set of behavioural responses on the part of the destination, d) a *rule* coupling some items from a) with some from b) or some from c) (Eco 1976: 36-7). The latter formulation, arguably and not unproblematically, has been most prevalent in semiotics although not always observed: code as a system of rules which links signs to meanings (e.g. Krampen 2010).

It is understandable that this formulation is so prevalent. The notion of code really only developed, especially in cryptographic terms, in the 19th century. As dictionaries of etymology will reveal, *code* has fraternity with the Latin *codex*, a book of laws; it is also related to *codicil* – an amendment to a document or a kind of over-writing of parts of a document. Subsequently, *code* was co-opted for what Singh (1999), in his popular science book, calls 'The mechanisation of secrecy' – sending encrypted messages. The code as a law, then, is imbricated with the sender and receiver's knowledge of the *rules* for decoding and the potential interceptor's lack of knowledge of those rules. Clearly, then, in this formulation, one can conceive of coding as having existed well before the 19th century – in early writing systems or even non-writing systems for accounting, such as the quipu of the Incas developed nearly 5,000 years ago (Ascher and Ascher 1997). Yet, like semiotics, which has a history pre-dating its emergence as a disciplinary field in the last hundred years, the common use of the word 'code' is recent, arising thousands of years into the process of routine coding by humans.

This point bears mentioning despite the fact that the purpose of this article is not to carry out the much needed tracking of the genealogy of code and coding. Instead, the focus here is on three simple points: that the term code has one prevalent meaning and some more general ones – as Hoffmeyer (2008: 83) notes, "the term has quite different connotations in different disciplines (e.g.,jurisprudence, genetics, computing)"; that the prevalent one is taken for granted in a way which is responsible for other slippages of the term; and that the pivotal moment in the fate of the conception of code arrived with Sebeok's development of zoosemiotics from 1963.

Taking contemporary semiotics as a source, it is clear that there are some leading definitions of code. In his final book, Sebeok (2001) repeatedly made reference to the five major codes: the immune code, the genetic code, the metabolic code, the neural code and, of course, the verbal code. Hoffmeyer (2008: 84-5) refers to code in general as the "customary use of distinct entities or actions for communicative ends" giving examples of a dress-code, a behavioural code, etc. He adds that semiotics sees code in the frame of context-free rules for encoding, transmission and decoding as posited centrally to Information Theory and in a looser version of code as a vehicle for creation of meaningful activity, a semiotic resource that enables the creation and expression of certain types of meaning but not others. Barbieri (2003, 2010), another biosemiotician who has a broad take on the issue, sees semiosis in the genetic code, at the very origin of life, with context-free codes only being superseded by interpretation 3 billion years later. Semiosis and interpretation, he adds, "are distinct processes" (2009: 239). In semiotics, it is clear, then, that much endeavour still needs to be carried out in order to work through the notion of code inherited from information theory and cryptography. Indeed, the information theoretic notion of code has even provided a strong debating point in biosemiotics despite the cogency of one the latter's inaugural texts on code duality (Hoffmeyer and Emmeche 1991). However, this article argues that Sebeok's use of

the term code evolved in a recognizable way during his first zoosemiotic period represented by the 1972 collection of Sebeok's essays, *Perspectives in Zoosemiotics*, as opposed to the second zoosemiotic period.[1] What exemplifies the two zoosemiotic periods in Sebeok's writing is the place of code – dissipating in the second period but, as will be seen in the focus here on the first period, in thrall not to information theory , in fact, but to an informationally-inflected linguistics (and, even so, already beginning the process of dissipation).

Sebeok's use of code

The essays in *Perspectives in Zoosemiotics* are, to invert a cliché, an unmixed bunch. As Sebeok admits in the Foreword (4), some themes are repeated and some issues are re-stated for the different purposes to which the essays were originally geared. Nevertheless, it does seem that there was development of the notion of code in relation to animal communication as Sebeok continued to write throughout the 1960s. By reading closely and reproducing a number of quotes, it is hoped that that development is made manifest. The initial formulations on code offered by 'Animal communication' (published 1965) are fairly straightforward:

> A code is that set of transformation rules whereby messages are converted from one representation to another, a message being a string generated by an application of a set of such rules, or an ordered selection from an agreed, that is, conventional, set of signs (1972: 75).

The traditional association of 'code' and 'rule' is invoked, as is 'transformation' - possibly, but not definitively, a nod to Chomskyan generative grammar and its influence during the period. In an earlier paper, published in 1962 but dating back to 1960, Sebeok states that

> By coding is meant an operation, governed by strict and logical rules, aimed at gaining increased efficiency by having elementary signals organized into patterns of alternative actions; by code is meant everything that the source and the receiver know *a priori* about the message (1972: 9)

'Rules' are evident here again, but Sebeok also has an explicit communication/information theory frame in the reference to 'source' and 'receiver'. This is not just a matter of context – Jakobson, one of Sebeok's key teachers (see Cobley et al 2011), had formulated 'context' in his celebrated communication model of 1960 as a matter of the "referent", but he formulated 'code' as "common to the addresser and addressee" (1960: 353). Echoing the latter, the key phrase in the quote from Sebeok is "*a priori*" – existent and not depending on the situation. Thus, in the first part of 'Semiotics and ethology', which appeared in German, Czech and Polish in 1966, Sebeok states that

> The source and the destination are therefore said to fully, or at least partially, share (d) a code, which may be defined as that set of transformation rules whereby messages can be converted from one representation to another (1972: 123).

This, then, is the general orientation of Sebeok's description of code in his early writings in zoosemiotics.

Sebeok's use of code – a closer look

If the delineation of code as an *a priori* rule is scrutinized further, it is clear that Sebeok's 'code' has specific sources. In his 1960 paper, Sebeok says of the human, "However, as to the code, his freedom is restricted: his selection must be made out of 'prefabricated units', among sets of simultaneous binary distinctions (Halle, 1957), elements in an algorithm (or decision procedure) concatenated into sequential patterns" (1972: 17). One telling phrase in this quote is repeated in his 'Animal communication' essay of 1965:

> The communicating organism's selection of a message out of its species-consistent code – as well as the receiving organism's apprehension of it – proceeds either in accordance with a genetic program dictating an almost wholly prefabricated set of responses with reference to each animal's unique memory store which then determines the way in which the genetic program is read (1972: 72).

The same phrase recurs a year later in the 'Semiotics and ethology' paper:

> In each species, the source of a message must share with its destination a code, the critical element of their communicative commerce constituting a particularized version of the universal 'need-to-know'. Every emitting organism's selection of a message out of its species-consistent code, as well as the receiving organism's apprehension of it, proceed either in accordance with a 'closed' prefabricated set of responses, or with reference to the animal's unique memory store which then directs the way in which the genetically precoded portion of the total behavior is acted out (1972: 129).

The key term in these quotes, to complement "*a priori*" here, is "prefabricated", as in the famous post-World War II housing, made in standardized form before construction and habitation. Code, as such, precedes communication.

The three sources for Sebeok's assertions about code are, in light of his central role in propelling international study of communication in the 1950s, predictable. They are (first order) cybernetics, communication theory and biology. A typical indicator of the influence of cybernetics can be seen in his 1964 'Discussion of communication processes' where he states that "the coding of information in cybernetic control processes and the consequences that are imposed by this categorization where living animals function as input/output linking devices in a biological version of the traditional information-theory circuit with a transcoder added" (1972: 84). This is clear cut. Slightly less clear cut, but typical of communication (and information) theory of the period if one is sufficiently acquainted with it, is the statement from the same 1964 source on

> the ultimate units of language, the atomic particles, if you will, of linguistic structure, organized in accordance with a binary code of utmost efficiency, so that whatever phase of the speech event is approached, the elicitation of its correlates must yield a distinct, unambiguous, 'yes' or 'no response" (1972: 86)

Also unsurprising for those with a basic knowledge of Sebeok's career and intellectual trajectory is the inflection towards biology in his statements on code. Yet, in the 'Foreword' to *Perspectives in Zoosemiotics* it is significant that he states that "I became a professional linguist and, alas forever, a geneticist manqué" (1972: 2). It is well known that Sebeok repeatedly defined himself as "a biologist manqué" (e.g. 1991: 9; 2011: 457), so defining

himself as a *geneticist* manqué in this one place is significant. Perhaps it suggests that the theme of coding that is so evident in this collection of essays is, ultimately, allied with the putative invariability of genetics. In the 1968 essay on 'Goals and limitations of the study of animal communication', Sebeok writes that "It is amply clear even now that the genetic code must be regarded as the most fundamental of all semiotic networks and therefore as the prototype for all other signaling systems used by animals including man" (1972: 117).

Yet, in spite of the prominence of cybernetics, communication theory and biology in the discussion of code which runs through these early zoosemiotics essays, there is also a further, over-arching factor. That factor is linguistics, in particular Jakobsonian linguistics. *Perspectives on Zoosemiotics* is dedicated to the geneticist who taught Sebeok at Chicago, Joseph J. Schwab; but the figure who haunts its earlier pages is Roman Jakobson. In the 1964 'Discussion of communication processes', Sebeok gives an account of some of the key features constituting the human animal, concluding with the set of tools with which humans are endowed, identified by linguistics as "universal building blocks of language: these are called 'distinctive features'" (1972: 86). In fact, his account of distinctive features is clearly inflected by communication/information theory. Thus, the quote on this topic given earlier can be reproduced here in expanded form:

> Distinctive features are the ultimate units of language, the atomic particles, if you will, of linguistic structure, organized in a binary code of utmost efficiency, so that whatever phase of the speech event is approached, the elicitation of its correlates must yield a distinct, unambiguous, 'yes' or 'no' response. What is basic and general in the structure of the expression in this form of human communication is, first, the minimal system of oppositions grounded on maximal distinctions; and, secondly, the rank order according to which this elementary phonological component pervades the more complicated syntactic and other constructions (1972: 86).

Sebeok, at this stage in his career, clearly considered distinctive features the "most concretely and substantively realized" (1972: 86) part of general linguistic theory, although he notes that the "phylogeny of distinctive features . . . has clearly not yet progressed beyond mere speculation" (1972: 88). To be clear, distinctive features are not the rules or code *per se*, but they are synonymous with the code to the extent that they constitute it. An analogous example might be football, where each individual kick or header or rebounding of the ball off the body is distinct but constitutes the code or rule by which handling the ball is outlawed. Jakobson had seen that the opposition of phonemes identified by Saussure (but, as Jakobson points out, introduced by the Polish linguist, Baudouin de Courtenay in 1870) was not a pure opposition, was susceptible of overlaps and was not sufficiently detailed to pronounce phonemes the basic, determinate units of language. Thus, in the 1940s and 1950s, Jakobson (Fant, Halle and Jakobson, 1952; Jakobson 1976) developed the theory of distinctive features in order to address the code underlying messages – that is, sounds more basic even than the phoneme; sounds that could not be reduced beyond their binary status.

Sebeok, communication and the 'language myth'

In positing the fundamental constituents of the code underlying messages, Sebeok and Jakobson were effectively participating in the millennia old practice of what Harris (1978) calls "the language myth". In an impressive body of work, Harris's outlining of the key problem embodied in the language myth is purposely simple. It is that (in three words)

"languages presuppose communication" (1978: 19); yet, in the face of this, the Western tradition of language study (as well as philosophy and then other areas of investigation, perfusing, ultimately, the laity and leading to a full-blown academic establishment called 'linguistics') has been intent on taking verbal communication apart, breaking it up into bits to attempt to determine what language is. This 'segregational view' "insists that 'the language' (the words, sentences, etc.) is one thing and what people do with it (or with them) another" (1996: 14). In the process of propounding a segregational view of language, successive 'administrators' of the Western tradition have taken as read that there are languages and parts of languages while, at best, only according secondary value to the fact that communication is a crucible of creativity in a swirling environment of changing contexts. Along with the larger myth, Harris identifies a number of sub-myths: the efficacy of dividing up speech to reach the 'essence of language'; sentences and propositions (especially in philosophy of language); language as facilitating telementation (especially espoused by Saussure); and the sub-myth that concerns the present article, the fixed code fallacy.

Jakobson veered towards a fixed code model of language chiefly through his rejection of Saussure's principle of linearity. Harris (2003: 96) points out that Jakobson chose an introductory passage on syntagms from Saussure's *Cours* and made the mistake of assuming that Saussure's principle of the impossibility of pronouncing two linguistic elements at once meant that two elements could not be *voiced* at once. The linearity principle seemed orientated towards context in that one element had to be processed in relation to another element; Jakobson's rejection of the principle led to his promoting distinctive features, sound distinctions at a level lower than the phoneme, which, as argued above, constitute a foundational, binary code. Jakobson's predilection for a theory of fixed codes in language was possibly a result of his interest in information theory in the 1950s, but it was also a logical product of 'segregational' linguistics.[2] 'Integrational' perspectives propounded by Harris (see, for example, Harris 1998) and focused on *communication* not *language*, insist that communication is co-temporal and wholly context-dependent. This means that the moment of communication is the crucial matter and that that which is *a priori* in communication is limited and by no means consists of cardinal rules. Another way of stating the 'integrationist' view is to say that it proceeds from the idea that the message is not ineluctably dependent on the code. (Indeed, for all his work on distinctive features, there is evidence to suggest that Jakobson's reading of Saussure did not necessarily amount to a generativist account of code and message – see Jakobson 1990c [originally 1942]). While segregationists have dissected messages to discover a determinate form or a code in language, integrationists are more comfortable with indeterminacy of form in communication (see Harris 2006: 39-42).

It is as well for zoosemiotics that the study of communication (as opposed to the study of language) has not been as slavish towards dividing messages and discovering codes. A central plank of animal communication studies for at least fifty years has been the insight that, when communicating, animals simply do not trade in the individual signs that might be demonstrated to be generated by a code. Rather, they send and receive 'whole' messages. One of the first ethologists to ruminate at length about this, Peter Marler (1961: 312), quoted by Sebeok in *Perspectives in Zoosemiotics*, wrote that

> in animal communication systems several items of information seem to be conveyed by one discrete, indivisible signal. We do not normally find the different items of information represented by different elements as is commonly the case in human language, where the component elements can be rearranged to create new 'messages'.

Since Marler wrote, this has become the accepted view in animal communication studies and has been borne out by much empirical research, such as that of Cheney and Seyfarth (1990; Seyfarth and Cheney 1993) into referentiality and specificity in vervet monkeys.

Certainly, Sebeok's later, 'fully semiotic' phase after the founding of the IASS in 1969 witnessed a different view on codes and coding from the context-free one. Looking back in 2001, he takes a jaundiced view of Birdwhistell's kinesics because the latter had "had minted this term by analogy with *linguistics* for the study of body motion from the point of view of how this may function as a communicative code" (2001a: xiii). In his later writings Sebeok referred to a proliferation of 'cultural' and 'natural' codes, from those in specific film genres to those in the social world of cats. He also treated the term 'code' as a synonym for 'interpretant' (see, for example, 2001a: 80 and 191 n. 13). Yet, even as the insights developed in zoosemiotics acted to question the theory of fixed codes in animal communication (including human communication), it is possible to see a change already during Sebeok's first zoosemiotic phase. In 'Zoosemiotic structures and social organization' (1970), Sebeok described different kinds of coding, (not unproblematically) considering Mozart's *Don Giovanni* to consist of a primary code – "natural language"; a secondary code – libretto; a tertiary code – score; and then the performance (1972: 164)[3]. Sebeok's 'fully semiotic' phase and the dissipation of his conception of codes as fixed is perhaps indicated in his late comment on "Jakobson's impact on my linguistics studies having been pivotal – I should add at once that it was far less so on my gradual evolution as a semiotician" (2011: 459).

The lessons of zoosemiotics

Nevertheless, while the advent of zoosemiotics cannot be taken just as the cue for dismantling the notion of fixed codes – a dismantling that has thoroughly penetrated linguistics in the last forty years but which was led by semiotics in general - it seems to be that in Sebeok's work and, by association, the institutional development of semiotics, zoosemiotics did have far-reaching consequences in respect of code. These are already prefigured in the 'first zoosemiotic phase' and can be whittled down to three related points that bear on semiotic research and theory: in 1968, Sebeok observed proscriptively that "descriptions of other sign systems tend to imitate (slavishly and erroneously) linguistics" (1972: 112); he noted that the "need for different kinds of theory at different levels of 'coding' appears to be a pressing task" (1972: 112); and, in 1972, he posed a key question for current investigation, "what is a sign, how does the environment and its turbulences impinge upon it, how did it come about?" (1972: 4). However, also in 1968, Sebeok remained convinced of the relation, as yet to be delineated, of the genetic and the verbal codes:

> the development of a normal neonate's faculty of language, which presumably includes a set of the universal primes of the verbal code, is wholly determined by the genetic code, but in such a way that this identical genetic blueprint can then find a variety of expressions in phenogeny through space and time (1972: 109).

In his research into the further reaches of the verbal code, the immune code, the metabolic code and the neural code, the importance of the genetic code's relation of determination was never absent.

The future of the theory of code in general is difficult to forecast: the institutionalisation of academic research, teaching and publishing has entailed that some disciplines and fields can flourish even when their key concepts have been demonstrated to be defunct. The short history of the concept of code has largely been associated with information theory and pursued vigorously by mathematics in particular. This accounts for its origins as a concept in the 19th century. Yet it should not be forgotten that 'code' has had an illustrious career in linguistics during the middle decades of the twentieth century. Arguably, linguistics, along with cryptography, was best placed to translate and prosecute the more demotic conceptions of code to be found in the popular imagination; conversely, semiotics, as a result of its fashionable period from the late 1960s to the mid-1980s, is probably responsible for the apotheosis of the demotic version of code as it has been promulgated in the 21st century by Dan Brown (whose fearlessness and erudition is so great that he never writes the word 'semiotics' – see Cobley 2007). The development of code in the work of Sebeok, and especially through zoosemiotics, has a slightly less vexed history, culminating in a pluralistic conception of codes coupled with an as yet unspecified determining role of the genetic master code. The development of zoosemiotics , it has been argued here, was instrumental in the dismantling of the concept of fixed codes in culture, even while semiotics was thought by some (cf. Eco 1976) to be a code theory (and later denigrated for that even as it made such a theory redundant). Furthermore, the relation between zoosemiotics and biosemiotics has even been misconstrued on this basis. A decade ago, Sebeok (2001a: 42) noted

> Some have suggested that "Biosemiotics has evolved from the study of animal communication to more general considerations of biological codes" (e.g., Peter Cariani in Van de Vijver et al. eds. 1998, 360). This, however, simplifies, even skews, an in truth far more labyrinthine sequence of events culminating in biosemiotics to which zoosemiotics is but one contributing factor (Sebeok 1998a, 10). This notwithstanding, zoosemiotics is doubtless "a particularly rich branch of biosemiotics because animals are in some sense semiosic mediators between creation and decay. On a macroscopic scale, they can be viewed as transforming agents fixed midway between the 'composer' plants, organisms that set interpretants in motion, and 'decomposer' fungi, which break them down," viz., between phytosemiosic and mycosemiosic operations. Too, in their role as go-betweens, animals process signs through media embracing the entire sensory spectrum, each - in conformity with [Jakob von Uexküll's] teachings - according to, but only commensurate with, its specific array of sense organs (Sebeok 1988a, 65; Sebeok 1997, 116).

The idea of a fixed code in linguistics, as Harris revealed so energetically, never really held up. Nor can it really be considered credible in its rigid sense in the world of culture suffused by verbality. Zoosemiotics, as a 50 year old disciplinary field has, like semiotics in general, a future which will be untrammeled by the information theoretic concept of code. It is the task of biosemiotics, not as an intellectual evolution of zoosemiotics but as a non-autonomous distinct theoretical paradigm, to establish what the relations are, on the one hand, between the genetic code in its degree of adherence to context-free coding and, on the other hand, cultural codes constantly embroiled in context.

Notes

[1] Maran (2010: 318) identifies the first zoosemiotic period as 1962-1969, although this could be put back to 1960 when Sebeok delivered his first zoosemiotic paper at Burg Wartenstein; the second zoosemiotic period of Sebeok is identified by Maran as 1975 to the end of the 1970s; but this, strictly, should also encompass the 1980 New York Academy Science colloquium on 'Clever Hans', the subsequent writings on the Clever Hans phenomenon in the 1980s and 1990s, and the essay on signifying behaviour in the domestic cat, published in 1994 but eventually included in Sebeok (2001).

[2] It is well known that Jakobson was very taken with the writings of Peirce from the 1950s onwards. Yet this does not guarantee a departure from code in favour of 'interpretation'. Peirce instituted his own version of code through the type/token distinction, as Harris (1996:10-12) recognizes. Jakobson focuses on this distinction, especially in the essays, 'Some questions of meaning' (1990a) and 'Quest for the essence of meaning' (1990b).

[3] A similar example appears in Sebeok (2001b).

References

Ascher, Marcia and Ascher, Robert (1997) *Mathematics of the Incas: Code of the Quipu*, New York: Dover.
Barbieri, Marcello (2003) *The Organic Codes: An Introduction to Semantic Biology*, Cambridge: Cambridge University Press.
Barbieri, Marcello (2009) 'A short history of biosemiotics', *Biosemiotics*, 2 (2): 221-245
Barbieri, Marcello (2010) 'On the origin of language: a bridge between biolinguistics and biosemiotics', *Biosemiotics*, 3 (2): 201–223.
Biggs, Norman L. (2008) *An Introduction to Information Communication and Cryptography*, Dordrecht: Springer.
Cheney, Dorothy L. and Seyfarth, Robert M. (1990) *How Monkeys See the World: Inside the Mind of Another Species*, Chicago: University of Chicago Press.
Cobley, Paul (2007) '"So we meet yet again": re-make, re-model, re-hash', *International Journal of Applied Semiotics* 5 (1/2): 233-248.
Cobley, Paul et al. (eds.) *"Semiotics Continues to Astonish": Thomas A. Sebeok and the Doctrine of Signs*, Berlin: de Gruyter Mouton.
Craig, Robert L. (2008) 'Code' in Wolfgang Donsbach (ed.) *International Encyclopedia of Communication*, 12 vols, New York: WileyBlackwell.
Donsbach, Wolfgang (2008) (ed.) *International Encyclopedia of Communication*, 12 vols, New York: WileyBlackwell.
Eco, Umberto (1976) *A Theory of Semiotics*, Bloomington: Indiana University Press.
Fant, Gunner C., Halle, Morris and Jakobson, Roman (1952) *Preliminaries to Speech Analysis*, Cambridge, MA.: MIT Press.
Hall, Stuart (1973) 'Encoding and decoding in the television discourse' Occasional Paper No. 7, Birmingham: Centre for Contemporary Cultural Studies pp. 1-12
Harris, Roy (1978) *The Language Myth*, London: Duckworth.
Harris, Roy (1996) *The Language Connection: Philosophy and Linguistics* Bristol: Thoemmes
Harris, Roy (1998) *Introduction to Integrational Linguistics*, Oxford: Pergamon.
Harris, Roy (2003) *Saussure and His Interpreters*, 2nd edition. Edinburgh: Edinburgh University Press.

Harris, Roy (2006) *Integrationist Notes and Papers 2003-2005*, Crediton: Tree Tongue.
Hoffmeyer, Jesper (2008): *Biosemiotics. An Examination into the Signs of Life and the Life of Signs*. Scranton: Scranton University Press.
Hoffmeyer, Jesper and Emmeche, Claus (1991) 'Code-duality and the semiotics of nature'in Myrdene Anderson and Floyd Merrell (eds.) *On Semiotic Modeling*, New York: Mouton de Gruyter.
Jakobson, Roman (1960) 'Linguistics and poetics: closing statement' in Thomas A. Sebeok (ed.) *Style in Language*, Cambridge, MA.: MIT Press.
Jakobson, Roman (1976) *Six Lectures on Sound and Meaning*, Hassocks: Harvester.
Jakobson, Roman (1990a) 'Some questions of meaning' in *On Language*, (eds.) Linda R. Waugh and Monique Monville-Burston, Cambridge, MA.: Harvard University Press.
Jakobson, Roman (1990b) 'Quest for the essence of meaning' in *On Language*, (eds.) Linda R. Waugh and Monique Monville-Burston, Cambridge, MA.: Harvard University Press.
Jakobson, Roman (1990c) 'Langue and parole: code and message' in *On Language*, (eds.) Linda R. Waugh and Monique Monville-Burston, Cambridge, MA.: Harvard University Press.
Krampen, Martin (2010) 'Code' in Marcel Danesi and Thomas A. Sebeok (eds.) *Encyclopedic Dictionary of Semiotics*, Berlin: de Gruyter Mouton.
Maran, Timo (2010) 'Why was Thomas A. Sebeok not a cognitive ethologist? From "animal mind" to "semiotic self"', *Biosemiotics*, 3 (3): 315–329.
Marler, Peter (1961) 'The logical analysis of animal communication', *Journal of Theoretical Biology* 1: 295-317.
McEliece, R. J. (2002) *Theory of Coding and Information*, 2nd edn. Cambridge: Cambridge University Press.
Sebeok, Thomas A. (1963) 'Communication among social bees; porpoises and sonar; man and dolphin', Language 39: 448–466.
Sebeok, Thomas A. (1972) *Perspectives in Zoosemiotics*, The Hague: Mouton.
Sebeok, Thomas A. (1991) *A Sign is Just a Sign*, Bloomington: Indiana University Press.
Sebeok, Thomas A. (2001a) *Global Semiotics*, Bloomington: Indiana University Press.
Sebeok, Thomas A. (2001b) 'Nonverbal communication' in Paul Cobley (ed.) *The Routledge Companion to Semiotics and Linguistics*, London: Routledge.
Seyfarth, Robert M. and Cheney, Dorothy L. (1993) 'Meaning, reference and intentionality in the natural vocalizations of monkeys' in H.L. Roitblat, et al (eds.) *Language and Communication: Comparative Perspectives*, Hillsdale, NJ : Lawrence Erlbaum Associates.
Singh, Simon (1999) *The Code Book: The Science of Secrecy from Ancient Egypt to Quantum Cryptography*, New York: Random.
Welsh, Dominic (1988) *Codes and Cryptography*, Oxford: Clarendon Press.